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Guest Editorial
Circuits and Systems for Flexible Electronics

THIS special section of the IEEE OPEN JOURNAL OF CIRCUITS AND SYSTEMS (OJCAS) is dedicated to the recent developments in circuits and systems for flexible electronics.

Flexible electronics is an emerging field that has huge growth potential in many applications ranging from wearables, smartphones, robots to entertainment, automotive, healthcare, and more. According to ReportLinker's latest report, global flexible electronics market is expected to grow by $15.16 billion during 2021-2025, progressing at a CAGR of 8.54% during the forecast period [A1]. This growth is further fueled by the rapid development in 5G, Artificial Intelligence, Internet-of-Things, smart healthcare, and advancement in materials. While novel devices and printing technologies provide the basic components and manufacturing process for flexible electronics, it is the innovation in circuits and systems that brings flexible sensors, interfacing circuits, embedded artificial intelligence, wireless communications, energy harvesting and wireless power transfer together to form a complete flexible system, which are essential for the ubiquitous deployment of sensors for data collection in the Artificial Intelligence-of-Things (AIoT) era. Flexible electronics opens a new field for circuits and systems (CAS) community to apply low power circuit techniques, design tools and methodologies, computationally efficient algorithms, and many more to tackle the challenges in making flexible systems.

This Special Section is a collection of five papers [A2]–[A6] that showcase latest works in flexible electronics ranging from the applications of flexible electronics, circuit techniques for wireless power and data transmissions, failure analysis for wearable sensors based on flexible printed circuit board (PCB), to recent developments in thin-film transistors and associated design kits.

The Special Section starts with a review paper [A2]. It provides an overview of recent advancements in flexible electronics for the BodyNET applications, where wearables, implants, and exoskeletons form a network around the human body for better healthcare outcomes and reinforced life quality. Core technologies for the BodyNET are reviewed including passive sensors, self-powered sensors, self-sustainable sensing systems, implantable medical devices, flexible sensors, and robotic exoskeletons. The challenges and future perspective of the BodyNET are discussed towards the end of paper.

Flexible wearable and implantable devices find many applications in healthcare as highlighted in [A2]. These bendable devices are normally restricted in weight and thickness for better conforming to human body shape and minimizing motion induced noises. Wireless power transfer provides a feasible solution to eliminate the need of battery on a flexible device by supplying power at a distance. [A3] presents a solution to remotely power a flexible sensor while facilitates data transmission with a single pair of coils.

The advancement of material science has produced many thin and stretchable materials for flexible electronics. However, they are not commercially available at reasonable cost. A cheap and commercially available solution is flexible PCB, which finds wide range of applications in wearable devices. [A4] presents the failure analysis of flexible PCB based sensors in free-living conditions and offers hints on how to avoid the failures, especially at contact points.

Thin-Film Transistor (TFT) is a perfect candidate to build circuits on flexible and stretchable substrate. The amorphous Indium Gallium Zinc Oxide (a-IGZO) TFT technology has shown its potential for many flexible applications. [A5] presents an overview of recent developments in state-of-the-art sensors based on a-IGZO TFT with focuses on analog and mixed-signal circuit designs and applications. It also offers some future research directions in the field of analog and mixed-signal circuit design with the a-IGZO TFT technology. [A6] introduces an open-source IGZO TFT PDK, which aims for fast adoption of the IGZO TFT technology by educators and researchers. A tensile force-insensitive standard cell library is introduced to speed up the design process with commercially available EDA tools.

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APPENDIX: RELATED ARTICLES

[A1] "Global Flexible Electronics Market 2021–2025," ReportLinker. Accessed: Oct. 15, 2021. [Online]. Available: https://www.reportlinker.com/p04103779/Global-Flexible-Electronics-Market.html?utm_source=GNW

[A2] T. He and C. Lee, "Evolving flexible sensors, wearable and implantable technologies towards BodyNET for advanced healthcare and reinforced life quality," *IEEE Open J. Circuits Syst.*, to be published, doi: 10.1109/OJCAS.2021.3123272.

[A3] L. Pan, M. Chen, Y. Chen, S. Zhu, and Y. Liu, "An energy-autonomous power-and-data telemetry circuit with digital-assisted-PLL-based BPSK demodulator for implantable flexible electronics applications," *IEEE Open J. Circuits Syst.*, to be published, doi: 10.1109/OJCAS.2021.3119931.

[A4] S. Critcher and T. J. Freeborn, "Flexible PCB failures from dynamic activity and their impacts on bioimpedance measurements: A wearable case study," *IEEE Open J. Circuits Syst.*, to be published, doi: 10.1109/OJCAS.2021.3122369.

[A5] M. Zulqarnain and E. Cantatore, "Analog and mixed signal circuit design techniques in flexible unipolar a-IGZO TFT technology: Challenges and recent trends," *IEEE Open J. Circuits Syst.*, to be published, doi: 10.1109/OJCAS.2021.3123206.

[A6] C. Ma *et al.*, "IGZO-TFT-PDK: Thin-film flexible electronics design kit, standard cell and design methodology," *IEEE Open J. Circuits Syst.*, to be published, doi: 10.1109/OJCAS.2021.3123396.

LIAN YONG (Fellow, IEEE) conducts research in the field of biomedical circuits and systems and signal processing. He has published more than 300 papers and received more than 15 awards, including the IEEE Circuits and Systems Society's Guillemin-Cauer Award, the IEEE Communications Society Multimedia Communications Best Paper Award, the Institution of Engineers Singapore Prestigious Engineering Achievement Award, and the Winner of the Design Contest of ISLPED2015.

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